Priority Needs for Network Validation

- Multiple radars (regional collaborations?) with large areal coverage
  - Dual polarization is highly desirable
- For non-DP radars, quality control of reflectivity data is critical but time-consuming
- Consistent & stable calibration is vital
  - GSFC/GPM Network Validation tool to match GV radar reflectivities with PR is available to all (Schwaller et al. 2007)
- High quality rain gauge networks with high temporal resolution
- Drop size distribution (DSD) characterization
- Snow depth/rate measurement where appropriate
- Vertical profiles of reflectivity
  - Bright band height, thickness
  - Low level reflectivity gradients
- Standardized GV Products (See suggested metrics)

GPM GV Partner Contributions

- ## Australia
  - BOM participates in IPWG regional validation activities for daily satellite precip estimate
  - Gauge-corrected radar data will also be used to validate shorter-period precip estimates using fuzzy (multi-scale) verification approaches
  - Australia will also participate in Validation Network activities described by Matt Schwaller

- ## Brazil
  - Statistical validation will compare satellite estimates to radar and gauge observations over land (various scales)
  - 25 operational radars (standardizing observation strategies)
  - Hourly rain gauge observations from AWS.
  - Parana State has a good measurement network. Brazil GV network could be put into a community database by regime.
  - La Plata Basin is a CLIVAR/GEWEX continental scale experiment
    - gauge mesonetwork, soil moisture, wx radar, flux tower, aerosol instruments, wind profiler, rawinsonde, lightning).
    - Fåield experiment PLATEX will extend from 2008-2012 (?), to include modeling and predictability research

- ## Canada
  - Focus on light precip, solid precip, and precip in mountainous terrain
  - Radars are all C-band except Montreal (S-band), and Montreal and King City are dual-polarized.

- ## Catalunya
  - Local network has 5 C-band Doppler radars, 390 automatic 10-minute gauges from 5 different agencies (making an effort to share data).
  - Around Barcelona in 20x20 km square there are 40 gauges.

GPM GV Partner Contributions

- Cyprus
    - Western Cyprus has a network of 125 daily gauges, plus a C-band Doppler radar.
    - Developing a network of automatic rain gauges at higher time resolution
    - Plan to install an X-band radar (specifications TBD)

- France
    - Megha-Tropique is set to be launched in 2009 with a focus on tropical rain, water vapor, and radiation budget
    - MADRAS microwave imager looks similar to TMI with additional 157 GHz channel
    - Half of the French radars will be polarized by 2010, but the sampling will be determined by Meteo-France.
        - 512x512 arrays of 1-km radar reflectivity, rain rate, Doppler every 5 minutes, polarization for 3 elevations.
        - Pluviometer data available for 24h accumulations (6 UTC to 6 UTC), also 6-minutes data from some gauges.

- Finland
    - Helsinki testbed with many instruments, and Sodankyla, which is a cal/val site for satellites and also a CEOP site.
    - 4 operational Doppler weather radars (FMI & EMHI), 1 Dual pol radar + one vertically pointing C-band radar for research (Vaisala & UH), 2 vertically pointing POSS-radars, 80 gauges, FD12P optical scatterometers, ultrasonic snow depth, weighing gauges

- Germany
    - National radar and rain gauge network with 16 C-band Doppler radars, all scheduled to be polarized by 2011, ~3000 gauges with daily observations,
    - ~1300 automatic gauges with 1-minute resolution.
    - The RADOLAN analysis (radar calibrated by gauges) is available hourly over Germany.
    - The GPCC has 1-degree monthly rain analyses, soon to be available daily also. They also have HOAPS data. The Hydrology SAF will be operational in 2010, with precip, snow, and soil moisture data and applications.

GPM GV Partner Contributions

- Italy
  - Network of radars is being developed
  - At least 10 of them will be dual-polarized.

- Netherlands
  - Two C-band radars, 325 manual daily gauges (08-08 UTC), 33 automatic 10-min gauges
  - Combined radar-gauge daily rainfall analyses for a 10-year period that can be used for pre-launch algorithm development.

- Spain
  - 17 regional meteorological services in Spain need to be coordinated into a national network.
  - If there is enough critical mass then could split into two groups, one for campaigns and one for long term evaluation.
  - Have some Spanish money, would like to get funding from European Science Foundation.

- UK
  - European framework for radar data has large areal coverage of 5-km resolution 15-minutes radar rain rates
  - This network will soon be expanded to include Spain, Scandinavia, and most of eastern Europe
  - OPERA is coordinating a European radar product
  - UK has 2000 hourly and 6000 daily gauge observations
  - IPWG/PEHRPP plans to have an intercomparison project to compare 3-hourly 0.25° precip estimates for the period 2004-2007, perhaps also include instantaneous rain rate comparison

Metrics for Validation of Space-borne Rain Estimates

- Need a routine & consistent set of metrics with which to compare satellite- and ground-based rainfall estimates

- Suggest recommendations of the WWRP/WGNE*, which listed several metrics for validation of NWP QPF estimates

* WWRP/WGNE Joint Working Group on Verification, 2004: Recommendations for the Verification and Intercomparison of QPFs form Operational NWP Models.

Basic Metric

- 1) Contingency tables
    - By season, regime, rain rate threshold, rain type, terrain type, scale, etc.

	Yes	**No**
Sat Yes	Hits	False Alarms
Sat No	Misses	Correct Rejections
	Val Yes	Val No

Derived Metrics

- ## Derived from Contingency Tables
  - Frequency Bias, Proportion Correct, Probability of Detection, False Alarm Ratio, Probability of False Detection, Equitable Threat Score, Hanssen and Kuipers Score, Heide Skill Score, others.

- ## Other important statistics
  - Probability Distributions
    - By occurrence and rain volume contribution
  - Mean, Sample Standard Deviation, Mean Error, Mean Absolute Error, Root Mean Square Error, Product Moment Correlation Coefficient, Scatter plots